The higher the moisture content of the air the less the daily differences and vice versa. This is generally, but not always, true.

I feel pretty certain that the dust content of the air affects the daily differences, but I am not yet able to establish the fact. Prof. Kimball has expressed the opinion that the blanket of moisture, smoke, and dust over a city tends to prevent radiation of heat at night, and during the day arrests much of the heat which reaches the suburban station. I see no reason to quesion this conclusion.

EVAPORATION IN THE CANAL ZONE.

By H. G. CORNTHWAITE, Chief Hydrographer.

[Dated: Balboa Heights, C. Z., Jan. 16, 1919.]

Evaporation is the process by which aqueous vapor is taken up from water surfaces and moist land areas and returned to the atmosphere. The water vapor in the air is derived primarily from the large ocean areas. It is carried about and distributed over the earth's surface by the prevailing winds. Condensation and precipitation complete the "meteorological cycle" and return the water to the earth's surface again in the form of rain or snow.

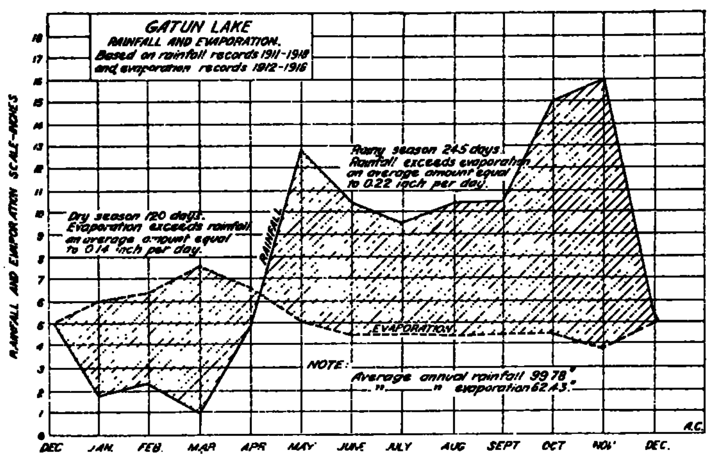

FIG. 1.—Gatun Lake rainfall and evaporation.

The laws of evaporation are complex and not thoroughly understood, but the principal factors controlling the rate of evaporation are wind movement, temperature, and vapor pressure. In regions such as the Canal Zone, where equable temperature conditions prevail, wind movement and vapor pressure are of paramount importance in controlling the rate of evaporation.

Since an adequate water supply is essential to the successful operation of the lock type of canal at Panama, the rate of evaporation from the surface of Gatun Lake has an important bearing on the successful operation of the canal, especially during the four dry-season months when the rainfall and run-off are deficient. In recent years valuable evaporation data have been collected at stations located at Bas Obispo, Rio Grande, and Brazos Brook reservoirs, and on Gatun Lake. These records are discussed herein.

Instrumental equipment.—The equipment at each evaporation station consists of a copper pan 4 feet in diameter and 10 inches deep. floating in the lake. An anemometer for recording the wind movement, a thermometer for registering the water temperature, and a rain gage for measuring the precipitation, complete the instrumental equipment of the station. The evaporation pan is protected from wave action by a wooden frame properly buoyed. In locating evaporation stations the aim has been to obtain conditions within and surrounding the pans as closely as possible approximating the conditions that prevail over the lake surface. The water level within the pans is maintained at approximately 4 inches below the top to prevent the overflow of the pan during heavy rains. A sharp-pointed copper index or zero point is set in the center of the pan. This index is protected by a 6-inch perforated copper cylinder still well, which serves to reduce the wave motion of the water surrounding the index, thus permitting more accurate readings of the daily evaporation.

Readings are made daily by measuring the quantity of water poured into the pan to bring the water surface exactly to the top of the copper index or zero point, due allowance being made for any rainfall that may have occurred since the previous reading. A measuring cup having exactly one one-hundredths the cross-section area of the evaporation pan is used in measuring the quantity of water poured into or removed from the pan.

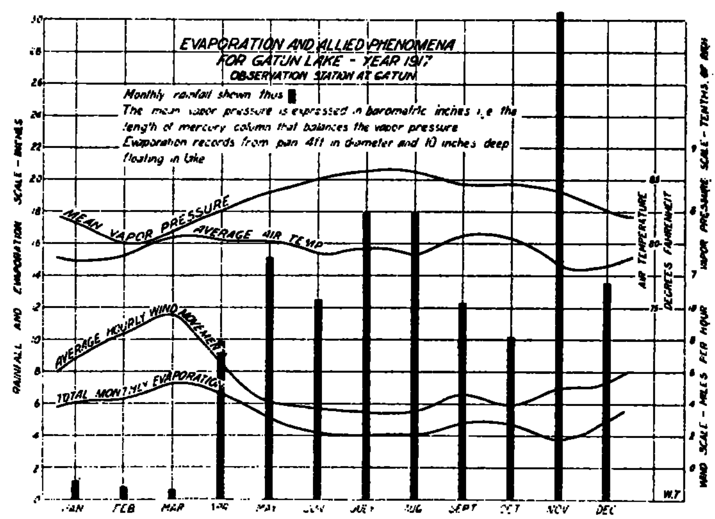

FIG. 2.—Gatun Lake evaporation and allied phenomena for the year 1917.

Evaporation records.—The average annual evaporation from a pan floating on the surface of Gatun Lake is approximately 62 inches. The rate of evaporation is much higher during the dry season than in the rainy season as the dry-season weather conditions favor a higher rate of evaporation. The higher wind movement, low humidity and vapor pressure, light cloudiness and higher day temperatures of the dry season all tend to accelerate the rate of evaporation.

The quantity of water lost from the surface of Gatun Lake during the four dry-season months is nearly as great as the quantity lost during the eight months of the rainy season. The greatest daily evaporation loss of record from Gatun Lake is 0.4 inch, occurring in March, 1918. Fig. 1 shows the relation between the rainfall and evaporation on the surface of Gatun Lake, while fig. 2 shows the relation between evaporation and its allied phenomena on the lake for the year 1917. The close parallelism of the monthly evaporation and the average wind velocity curves is noticeable; also the inverse relationship of the rainfall and evaporation curves.

Day- and night-time evaporation.—Comparative records of the day and night evaporation indicate that approximately 60 per cent of the evaporation loss occurs during the daytime, 8 a. m. to 8 p. m., and 40 per cent at night. Comparative day and night evaporation records are given in Table 1.

Variations in rate of evaporation.—Evaporation records were obtained from selected locations on Gatun Lake, to determine the relative rates of evaporation from the open sections of the lake and along the grass and timber covered margins. One floating pan was anchored well out in the open section of the lake. Another was located in the timber fringe bordering the south shore and a third was placed in the midst of a grassy marsh. The records were continued for six months during the rainy season, with the following results:

Evaporation from open lake, 100 per cent.
Evaporation from timber fringe, 72 per cent.
Evaporation from grassy marsh, 75 per cent.

The higher rate of evaporation from the open sections of the lake is due, principally, to the greater wind movement there, which tends to prevent the accumulation of a vapor blanket directly overlying the water surface. The rate of evaporation from the protected margin of the lake varies, depending upon the degree of protection from wind movement and direct solar radiation.

Best exposure.—Evaporation records from pans floating in lake or reservoir are considered about as accurate and representative as can be obtained under natural conditions of exposure. They are thought to be more reliable than records from pans exposed on the land surface, but care should be taken not to place the floating pan in a location too freely exposed to high winds and heavy wave action, or inaccurate records may be obtained, due to the splashing of water into or out of the pan.

Dry-season evaporation records are considered more accurate than the rainy-season records, as occasional heavy downpours in the rainy season may impair the accuracy of the records, on account of an inequality in the catch of rainfall in the evaporation pan and in the rain gage.

Monthly evaporation records at Canal Zone stations are given in Table 2, while figure 3 shows a view of a typical lake evaporation station.

TABLE 1.—*Comparative values for day and night.*[1]

Month.	1908[2]						1909			
	Ancon.		Bas Obispo.		Cristobal.		Ancon.		Cristobal.	
	Day.	Night.	Day.	Night.	Day.	Night.	Day.	Night.	Day.	Night.
	Ins.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
January	......	......	......	......	......	......	1.755	1.593	2.754	2.114
February	5.062	1.495	3.605	2.124	4.200	3.758	2.134	1.594	2.916	2.437
March	5.566	1.431	3.919	2.371	4.402	3.155	2.693	2.238	3.660	2.785
April	4.404	1.517	3.630	1.845	3.999	2.931	2.108	1.775	3.594	2.873
May	2.001	1.218	1.715	1.460	1.706	0.864	1.317	1.134	2.268	1.600
June	2.034	1.012	1.955	1.460	1.878	1.306	0.941	0.975	1.332	1.166
July	1.900	1.117	1.670	1.580	1.584	1.238	1.078	1.002	1.252	1.193
August	2.175	1.028	1.702	1.723	1.985	1.207	1.241	1.030	1.467	1.169
September	1.924	1.125	2.178	1.457	2.096	1.231	1.425	1.059	1.706	1.021
October	2.051	1.205	2.467	1.408	2.016	1.308	1.862	0.964	1.784	1.243
November	1.362	1.052	1.555	1.175	1.572	1.128	1.395	0.937	1.129	0.821
December	1.337	1.605	2.040	1.405	2.252	1.804	1.775	1.245	1.484	1.262
Total	29.816	13.805	26.436	18.008	27.690	19.930	19.724	15.546	25.346	19.684
Per cent	68	32	60	40	58	42	56	44	56	44

[1] Readings taken at 8 a. m. and 8 p. m. daily.
[2] 11 months, 1908.
Exposed concrete tank 12½ feet in diameter at Bas Obispo. Protected tanks 10 inches in diameter at Ancon and Cristobal.

TABLE 2.—*Monthly evaporation records.*[1]

BAS OBISPO.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
	Ins.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
1907	5.175	5.072	6.538	6.486	4.681	3.125	3.152	3.582	3.358	2.938	3.599	4.896	52.602
1908	5.617	5.729	6.290	5.475	3.175	3.415	3.250	3.425	3.635	3.875	2.730	3.445	50.061

RIO GRANDE.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1909	.....	.....	.....	5.960	4.205	3.417	3.117	3.353	3.768	3.094	2.713	2.993	......
1910	4.612	5.529	6.003	3.986	3.916	2.654	2.846	3.096	3.677	3.577	2.999	3.442	46.337
1911	5.940	4.912	7.462	5.139	4.015	3.646	4.989	4.564	4.096	3.924	3.055	5.344	57.086
1912	6.363	6.134	7.099	6.732	5.350	3.836	3.908	3.983	3.335	3.763	3.275	4.723	58.501
1913	5.392	5.544	6.762	6.436	4.033	3.812	3.963	3.901	3.783	3.758	2.741	4.525	54.950
1914	5.520	5.965	7.062	6.413	4.870	3.733	5.084	4.520	(2)	(2)	(2)	(2)	(2)

BRAZOS BROOK.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1909	.....	.....	.....	5.366	4.597	3.806	3.042	3.760	4.169	4.168	2.152	2.379	......
1910	4.622	4.668	6.151	5.025	4.304	3.516	3.014	3.189	3.804	4.177	2.718	2.746	47.934
1911	6.293	5.115	6.872	4.939	3.290	2.917	4.358	4.066	4.101	3.937	3.364	5.176	54.428
1912	6.066	5.572	7.081	7.321	5.707	3.729	4.425	[illegible]	4.487	3.970	3.100	4.860	60.929
1913	6.387	6.616	8.455	7.466	4.167	4.500	4.277	[illegible]	4.934	4.343	3.071	4.747	63.211
1914	6.331	6.456	7.769	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

GATUN LAKE.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1911	.....	.....	.....	.....	......	2.799	4.560	4.407	4.583	3.609	2.681	3.376	......
1912	7.208	6.048	7.649	7.394	5.335	3.263	3.889	4.316	3.799	4.123	3.351	4.809	61.184
1913	5.435	6.889	8.602	7.333	4.606	5.083	4.664	4.570	4.934	4.844	3.560	1.291	64.811
1914	4.821	6.298	7.504	6.688	5.262	4.558	5.520	4.684	4.074	4.233	4.180	5.083	62.905
1915	6.398	5.430	6.698	5.781	5.361	5.040	4.107	4.354	4.315	4.228	3.564	4.656	59.932
1916	6.280	5.985	6.424	6.391	5.290	4.430	4.491	4.793	4.545	4.267	3.797	4.865	61.558
1917	6.194	6.229	7.246	6.514	4.903	4.110	3.903	4.008	4.851	4.750	3.617	4.899	61.224
1918	5.548	7.231	8.475	6.502	4.901	4.859	4.690	3.991	4.577	4.127	4.621	5.881	65.403

[1] Records from exposed concrete tank 12½ feet in diameter at Bas Obispo.
[2] Station closed.
Exposed pans 4 feet in diameter and 10 inches deep, floating in water at Rio Grande, Brazos Brook, and Gatun Lake.

EVAPORATION COMPARED WITH VAPOR PRESSURE DEFICIT AND WIND VELOCITY.

By EARL S. JOHNSTON, Associate Plant Physiologist.

[Dated: Maryland Agricultural Experiment Station, College Park, Md., Jan. 31, 1919.]

Atmospheric moisture plays an important rôle in the growth and behavior of plants and can not be overlooked in physiological and ecological studies. Atmospheric moisture conditions have frequently been studied by means of atmometers and the rate at which these instruments lose water has been taken as a measure of the evaporating power of the air.[1] The rate of evaporation from these instruments as well as the rate of transpiration from plants is greatly influenced by wind, by the temperature of the surface as dependent on radiant energy and air temperature, and by the amount of water vapor present in the atmosphere. Many attempts have been made to show a relationship between these conditions and the amount of evaporation, but most of the equations formulated are of little value in field

[1] Objections have frequently been made to the expression "evaporating power of the air." Strictly speaking, the air by its presence hinders the rate of evaporation. The term here used is defined by Dr. B. E. Livingston. "Atmospheric evaporating power refers to the external surroundings of the evaporating surface (usually to the air space above it, about it, etc.) and it need not specially refer to the air itself, for if there were no air present this space would still possess an evaporating power. The evaporating power of the air over a surface is considered as proportional to the reciprocal of the tendency of all the conditions effective in the space over that surface to resist the vaporization of water therefrom." Atmometric units. Johns Hopkins Univ. Cir., March, 1917, p. 160-170. (See especially p. 161.) Other expressions such as "potential evaporation" and "evaporativity" have been suggested.